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OBSERVATIONS ON *BOMBUS* AND *PSITHYRUS*, ESPECIALLY ON THEIR HIBERNATION

By Prof. J. H. Bols.

(*Lubbeek, Belgium.*)

Communicated by O. W. Richards, M.A., D.Sc., F.R.E.S.

With Plate 1.

A. *The " Summer-camp."*

1. *The discovery of the camp, on 22nd June.*

At about 10 a.m. on a sunny morning, I was walking along a steep, plant-covered, sandy bank, using my shadow as an expedient for discovering the little curved " chimneys " of *Odynerus* ; soon many were found as well as four specimens of *Bufo calamita* Laur. which were sitting at the entrance of what seemed to be mole- or mouse-holes. The method of making a shadow pass rapidly over a bank in order to discover *Cicindela*-burrows and other insect-galleries is a good one, which I have used for fifty years. Insects also guide themselves by shadows, and I once obtained ten specimens of *Megachile ericetorum* Lep. by making small holes in the ground, which the females came down to and entered. Apparently humble-bees guide themselves by looking for the dark apertures of burrows in the same way. On the morning in question, a dense procession of female *Bombus* and *Psithyrus* was seen flying one after another on a circular course, inspecting the shadows made by all holes. By following them it was possible to define approximately the area of the " summer-camp." These processions took place every morning before noon, and the species taking part in them were *Bombus lapidarius* (L.), *B. ruderatus* (Fab.), *Psithyrus rupestris* (Fab.) and *Ps. campestris* (Pz.). At this date *B. agrorum* (Fab.) (the host of *Ps. campestris*) was no longer present and *B. terrestris* (L.) and its parasite *Ps. vestalis* (Geoffr. *in* Fourcr.) were also absent. The *Bombus* and *Psithyrus* seemed to take no notice of one another and it was not a case of a parasite shadowing its host. Apparently the camp must be the remains of an assemblage which overwintered there and the females were partly making orientation flights, partly searching for nesting-places. These flights continued on mornings throughout June, perhaps for as long as the camp was used for sleeping-quarters at night.

2. *Observations on the use of the camp as a night-refuge.*

The following observations were made every day at the end of June at about 6 p.m. in the evening.

26th June. In an area comprising about ten square yards, in one hour, fifty *Psithyrus rupestris* ♀♀ and thirty *Bombus ruderatus* ♀♀ were counted creeping under the leaf-mould to spend the night. They were not digging but merely creeping under the loose surface. A female of *Ps. rupestris* was observed more closely. She came into this corner of the camp, deeply humming as *Psithyrus*-females always do in the early summer, flying so close to the ground that leaf fragments or even whole dead leaves were churned up by the strokes of her wings. She stopped at the open winter-burrow of some humble-bee and crept in, remaining inside for about ten minutes. She then came out backwards pushing out a little heap of sand-grains with her tail. She re-entered backwards, but after one minute came out and abandoned the hole. She *ran* (on the tips of her legs, with her wings beating) further into the area and, after travelling about fifteen inches, crept under the leaf-mould. The action of running on the tips of the legs with the wings still beating is the characteristic way in which all *Bombus* and *Psithyrus* land after flying.

Psithyrus rupestris and *Ps. campestris* may burrow within five inches of one another without being at all disturbed. The former species is the most powerful of all these bees and very quickly forces its way under the leaf-mould, in about five minutes raising a mound as large as the palm of a man's hand. The abundance of *Psithyrus* may, perhaps, partly account for the complaints by farmers near Lubbeek of shortage of clover-seed, owing to the check which the parasites exercise on *Bombus*-colonies.

Bombus ruderatus behaves in a much more hesitant way than *Psithyrus* and takes longer to get under cover. By 8 p.m. it is dusk and all the *Bombus* are under cover, but every five minutes odd females of *Ps. rupestris* can still be heard arriving.

On 28th June, at 6 p.m., only *B. ruderatus* were observed, no *Ps. rupestris*, though these had been in a majority two days before. Five *Bombus* were seen coming in abreast to the one area of ten square yards. Two yards away another female was seen, and a second one was burrowing at my feet. They do not dig but merely force their way under the mould.

On 29th June only *Ps. rupestris* were seen, first three, then five together.

On 3rd July one female *Bombus lapidarius* came and bit for a short time at the moss but did not creep in. One dead female of *B. ruderatus* was found with a large hole in her abdomen, on the dorsal side anteriorly.

On 6th July the following females were seen :—one *B. lapidarius*, one *B. agrorum*, one *Ps. campestris*, one *Ps. rupestris*.

On 8th July the area of ten square yards and, indeed, the whole camp was deserted and it remained so thereafter until 14th August.

B. *Observations on the males, 24th July to 14th October.*

The males were found flying in a large woodland glade leading to the camp. Here grew ten large clumps of bracken. In the sun, above each clump, were flying seven or eight males of *Bombus* and *Psithyrus*. The species could not be recognised owing to the rapidity of their flight. Every ten minutes or so, one of them would alight on the curved mid-rib of a bracken-frond and run along it. Gatherings of this sort round the bracken went on till 28th September. By this time many had been caught in the webs of *Epeira diadema* Cl. and the others had probably fallen exhausted. It was interesting that in this second period *only* males were present, whereas earlier there had been only females. Throughout July–August, processions of males were also seen. A male came every thirty seconds or every minute, flying very rapidly and silently, each one heading for the same spot, at the foot of a small oak-bush on a bank. They all alighted there on the same dry oak-leaf on the ground, creeping rapidly over it and then flying on. At the same time, in another place about thirty yards away, there were two spots in the sun being visited at the foot of a small birch-tree, not growing on the bank. They always flew first to the one in front and then to the one on the right side, always *without* alighting. In neither place was there anything special to be seen. Possibly these places which are visited retain traces of some scent, perhaps of a virgin female. But on no occasion was any copulation observed throughout the whole period of observations. The males engaging in these processions are very nervous and alert, and they were seen up to early October.

C. *Excavation of hibernation-burrows by the females.*

On 14th August part of the camp was observed at 3 p.m. on a fine sunny day with a south-west wind. The slope had a north-west exposure and was of sand, covered with short moss (*Barbula*) and leaf-mould. A fresh heap (5–7 thimblefuls) of fresh yellow sand was noticed. It was found that through the friable, grey surface sand went a cylinder ($\frac{1}{2}''$ diameter) of damp yellow sand. The cylinder was four or five inches long and led down to a spherical chamber of about the size of a walnut. In this, lying on her back, was a fresh female of *Psithyrus vestalis*, with quivering wings. When disturbed she emitted shrill chirps, but did not hum.

Soon another burrow was found close by, and on this, the first day of observation, five *Ps. vestalis* females were dug up.

On 15th August at 10 a.m., another warm day, a female *Ps. vestalis* was seen coming to dig. She ran along, vibrating her wings, and soon began to bite into the moss, pushing the loose bits from under her abdomen into a heap. When she was half hidden, a second female came, and, after circling slowly, alighted on the tip of the abdomen of the first one, which, however, took no notice but went on digging. The second female soon flew away. The first female continued digging, boring into the sand methodically, turning in all directions. The debris made a ring surrounding the entrance, owing to the way she pushed the sand out on each side in turn. Every one or two minutes she came right out backwards. After half an hour she was already deep enough to be almost completely hidden and observations were concluded. Next morning the burrow was found to be completed. It is evident that the stopper of the burrow is formed merely by sand pushed up from below, probably mainly that obtained in the formation of the spherical chamber.

The female always lies on her back in the chamber, usually with her left wings over her right; she can easily reach the roof with her legs. All the species of *Bombus* and *Psithyrus* observed make similar hibernacula in this way.

On the following days, sample burrows were excavated to identify the species, with the following results :—16th August, 1 *Ps. rupestris*, 1 *Ps. vestalis* ; 17th August, 1 *Ps. rupestris*, 1 *Ps. vestalis* ; 19th August, 4 *Ps. rupestris*, 1 *Ps. vestalis*, 1 *Ps. barbutellus* (K.). On later days mainly *Ps. campestris* was found, with a very few *Bombus*.

It was thought at first, in view of the number of individuals leaving the camp in the spring, that it would be equally populous in the autumn. It was found, however, that the females always came in small groups of five or seven and that they started digging at once. At no time, therefore, was the area humming with bees. But as every morning about half a dozen new burrows would be found, and, as the rain washed away all external traces of many, it is possible that the bees were really present in quite large numbers.

In 1936 the harvest of clover-seed in the neighbourhood of Lubbeek was much below the average. This is usually supposed to be the result of a wet season. In 1936, however, when the clover was in flower, the weather was hot and dry. The shortage of seed may be ascribed with some probability to the absence of a sufficient number of *Bombus* to fertilise the flowers. The absence of *Bombus* may, perhaps, be explained partly by a temporary increase in the numbers of *Psithyrus* and partly by the drought in the spring when the bees were attempting to establish their nests.

It must be supposed that many of the bees came to the camp from considerable distances. A search for nests in the neighbourhood, made both by the author and by school-children, revealed only one nest of *B. lapidarius* (21st August, at least 200 individuals, including males but no *Psithyrus*) and one of *B. agrorum.*

The camp-area is in part becoming very much overgrown with brambles. This is almost certainly driving off the humble-bees. The same process is often seen in colonies of *Ammophila*, *Philanthus*, *Bembix*, etc., on sandy soil, though the Sphecoids object even more to a plant-covering. Nevertheless, where the soil is suitable and where there is a N.W. exposure, the humble-bees may burrow in invaded ground, at any rate where there are hazels. By going on hands and knees, the burrows of about half a dozen *Psithyrus* females were found in such a situation.

Although Sladen and Plath have made extensive observations on the hibernation of humble-bees, it appears that the aggregation of many individuals into a definite " camp " as in the present instance is very unusual.*

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* Dr. E. A. Cockayne has kindly communicated the following observation.

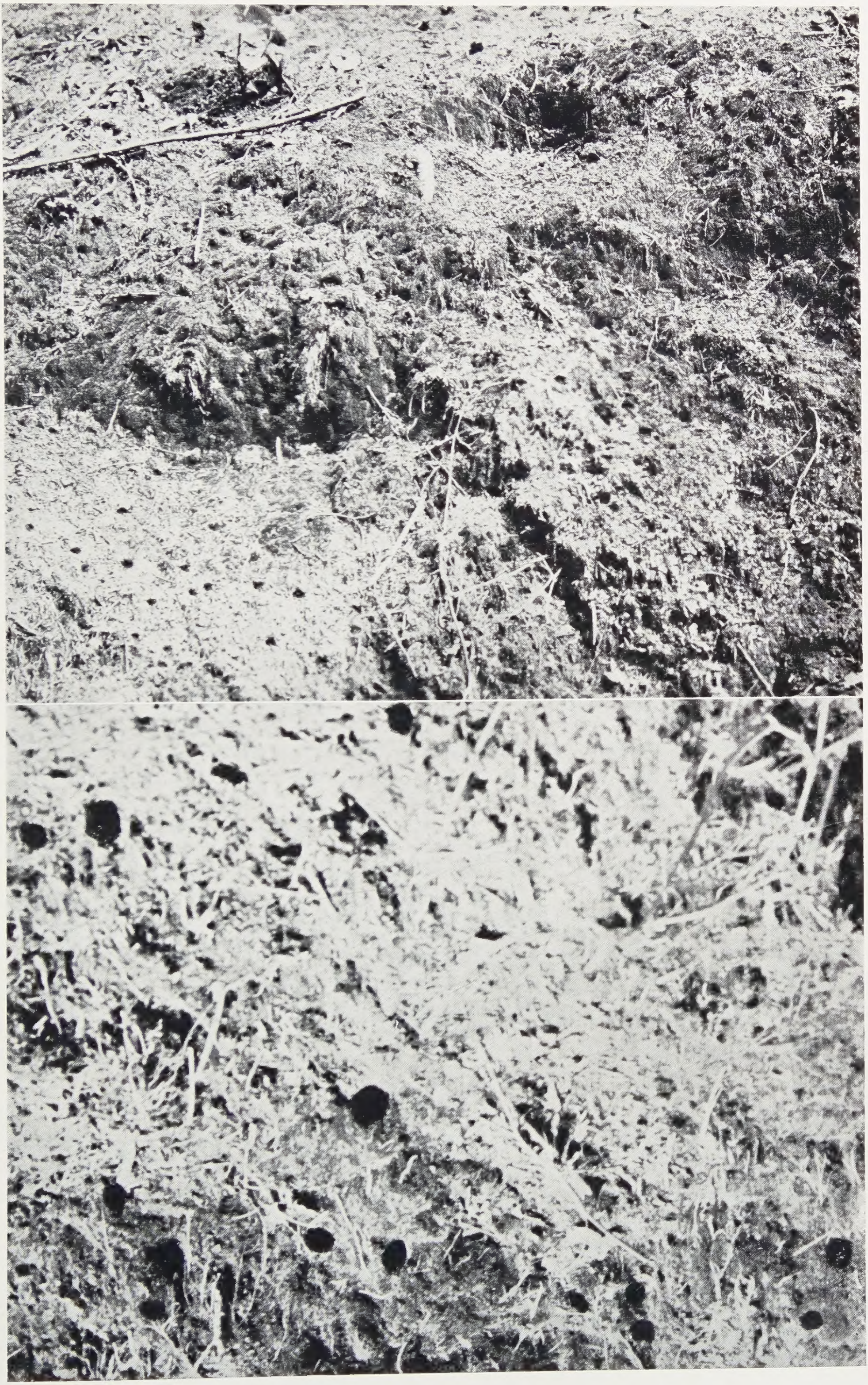
" When I was about eleven years old I stayed at Owmby Cliff, ten miles north of Lincoln. In a field near the house there was a small pond with a mound on each side, and in the bank facing west or south-west large numbers of females of a black humble-bee with a red tip to the abdomen were busy day after day making holes in the bank. I dug some out and found the holes were quite short. There were no bees burrowing in the opposite mound."

Mr. A. H. Hamm, on reading the Abstract of Prof. Bols' communication, wrote a letter of which the following is the gist.

" Many years ago, I think in 1903, I visited the late Mr. F. W. L. Sladen, in connection with the export of female *Bombus* to New Zealand. While I was staying with him at Ripple Court, Dover, he took me to a site where many could be found, though it was still early August. We found a number of their scratchings, rather like rabbit-scratchings in miniature, and I understood from him that this was a yearly occurrence. To the best of my recollection, the bank faced north or nearly so. Here in Oxford, the only place where I have seen them most years is the foot of the boundary wall of the Museum grounds, opposite Keble College. A single female was first noticed burrowing, and observation then showed that others were doing the same during the autumn. This was afterwards noticed in most years. I have only twice found a female in my own garden at Oxford; both times by accident, when I was digging in the winter."

EXPLANATION OF PLATE 1.

FIG. 1. Part of the " winter camp " of *Bombus* and *Psithyrus*. (Photo. J. H. Bols.)
2. The same, more enlarged.



ENGRAVED BY STAR ILLUSTRATION, LONDON.

The "Winter Camp" of *Bombus* and *Psithyrus*.

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AN OBSERVATION ON *BOMBUS TERRESTRIS* LINN.

By Dr. Hugh Scott, F.R.E.S.

Professor Bols's communication reminded me of an observation, not previously published, of which I have never succeeded in getting any explanation. On August 26th, 1931, a really hot day in a spell of fine weather during a season generally broken and wet, I walked along the left bank of the river Ure between Boroughbridge and Newby Hall, a few miles south-east of Ripon, Yorks. I saw large numbers of a species of *Bombus* swarming in and out of a hole, apparently the entrance to their nest, in sandy soil on the river bank. Many workers of different sizes were pushing their way *into*, as well as out of, the hole, flying round in curves and returning to it, and among them was one very large queen; so far as could be seen, no males were present. I had no means of collecting a specimen, but the type of colouring was that of *Bombus terrestris*, and I have little doubt that this was the species. At the time I wondered whether I was witnessing an end-of-season dispersal of the community, or whether the phenomenon was due to some other cause.

No explanation could be found in F. W. L. Sladen, 1912, *The Humble Bee*, or elsewhere, and hymenopterists whom I asked could furnish none. Dr. W. B. R. Laidlaw, who at that time was publishing notes on the biology of humble-bees,* wrote (10.xi.1931), in answer to an inquiry, that he had always found virgin queens of *Bombus terrestris* to be the latest in appearing of any British species, August 20th being the earliest date he had for their appearance. Dr. Laidlaw, therefore, thought the emergence of young queens was a probable explanation, and that the warm day would favour it; but he added that he had never seen anything resembling the incident, and further suggested that a mouse (or some other intruder) might have disturbed the community, since bees are a source of diet to mice. Against the emergence of young queens are the facts that only one large queen was seen, all the rest were small females, probably workers, and that there was a return movement into, as well as the emergence from, the hole. Moreover, since only one queen was present, the incident could not have been an example of the phenomenon described by Professor Bols. It must remain, apparently, unexplained.

* W. B. R. Laidlaw, 1930, Humble bees and wasps in Scotland, *Scott. Nat.*, **1930** : 121–5, 135–6; 1931, Additional notes on humble bees in Scotland, *op. cit.* **1931** : 23–4; 1931, Notes and observations on humble bees in Aberdeen, *op. cit.* **1931** : 181–3; 1932, Gynandromorphic *Bombus* and other notes on bees and wasps in Scotland, *op. cit.* **1932** : 25–7.

Book Notice.

Introducing British Butterflies. By H. Bastin. Sm. 8vo. London, Philip Allan. 1937. 2*s.* 0*d.* pp. 80, 8 pls.

This small volume is addressed to beginners and young people. The first 40 pages are devoted to a general introduction to the British butterflies, followed by a systematic table giving time of appearance, terrain frequented, food-plants and stage in which the species hibernates. On the eight plates are printed half-tone illustrations of some characteristic species and the book is completed by a chapter " Round the year with the butterflies." The size of the volume makes it quite suitable for transport in the pocket.

EXCRETION DURING COCOON SPINNING IN *TROPHOCAMPA* (*CASINARIA*) *VIDUA* GRAV.

By Miss D. J. Jackson, F.R.E.S.

This species is a common parasite of the caterpillars of *Abraxas grossulariata* at St. Andrews. Oviposition is effected during the early part of August in the very young caterpillars, and the parasite larva is full grown and ready to emerge in the following June. It then spins its cocoons on a leaf or branch beside the shrunken remains of the caterpillar. While spinning the outer layers of the cocoon the larva ejects from the anus drops of colourless liquid through the mesh of the cocoon. The surface of the cocoon becomes beaded with about 40 to 70 drops. The fluid is derived solely from the Malpighian tubules which open into the anterior end of the hind gut, since at the time of excretion the mid gut does not communicate with the hind gut. After completing the cocoon the larva excretes within it a little clear gelatinous fluid, which is probably the residual fluid in the hind gut. Later, during the prepupal period, the lumen of the mid and hind gut is continuous and the contents of the mid gut are expelled, enclosed in the sac-like peritrophic membrane.

Mr. W. R. Brough Hynd has made a preliminary micro-chemical examination of the various excreta and his results seem to show that the drops of fluid consist of an aqueous solution of chlorides and reducing sugars : the gelatinous excrement contains protein ; while the more solid excrement within the sac gave a strong uric acid reaction.

The cocoon varies in colour according to whether it is spun in dry or damp surroundings, being either whitish or fawn colour, with two dark bands. White cocoons become fawn if placed in a moist atmosphere and the colour remains when the cocoon is dried. Przibram has shown that in certain cocoons of moths and sawflies, dioxyphenylalanine (" dopa ") is present, and that, in the presence of water in an alkaline medium, this produces melanin by oxidation. There is little doubt that the colour change in the cocoon of *Trophocampa* is to be explained in the same way.

It is hoped to carry out further investigations on cocoon-formation and excretion in *T. vidua* this season and to publish the full results later.

Reference.

Przibram, H. 1924. *Arch. mikr. Anat. EntwMech.*, **102** : 624–634.

Book Notice.

The beauty of butterflies. 12 coloured plates with introductory text, 8 pp., by Prof. A. Portmann. 4to. London, B. T. Batsford, Ltd., n.d. 5*s.* 6*d.*

This book is one of a series entitled " Art and Nature in Colour " and is the English counterpart of a French and German edition.

The excellent illustrations are remarkably good specimens of colour photography well printed on a non-coated paper.

The text and plates are printed in Switzerland.

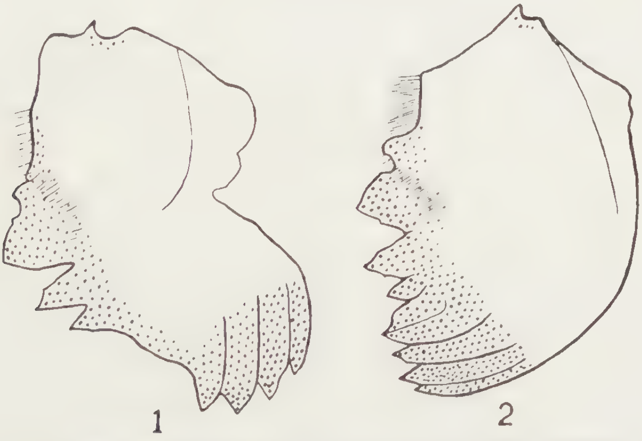
A number of finely coloured butterflies is depicted.

AN ABNORMAL MANDIBLE IN THE DESERT LOCUST (*SCHISTOCERCA GREGARIA* FORSK.)

By A. G. Hamilton, B.Sc., B.Agr., Ph.D., D.I.C., F.R.E.S.

In the course of the breeding of the Desert Locust in the Locust Research Laboratory of the Imperial Institute of Entomology, two adults (♂ and ♀) of this species were observed with an abnormal left mandible. Both were found in the same cage and were the F_2 generation of a stock which had been received from Egypt. The type of cage and the method of controlling the temperature and the humidity have been described in an earlier paper (Hamilton, 1936). There were 71 hoppers at the beginning of the breeding experiment and 57 (80·3%) reached the adult stage. The temperature of the cage was 90° F. (32·2° C.) and the average relative humidity 70%.

At first it appeared as if there was an additional distal toothed incisor lobe arising from the end of the mandible as it projected below the labrum. This affected the locusts to such an extent that they were unable to feed, which suggests that the abnormality had occurred during the final moult and that the mandibles must have been normal or almost so, during the hopper stages, otherwise the hoppers would have been unable to feed and would therefore have died during the first instar. The time required by the hoppers to reach the adult stage was normal for the conditions of temperature and humidity in the cage.



Figs. 1–2.—(1) An abnormal left mandible of a male *Schistocerca gregaria*; (2) A normal left mandible of a male *Schistocerca gregaria*.

If the abnormal left mandible (fig. 1) is compared with the normal left mandible (fig. 2) it will be seen that the abnormality is due to the distal toothed incisor lobe having been twisted and pulled forward, drawing the proximal molar lobe into the normal position of the former lobe. This twisting of the mandible appears to be due to the head of the adult not freeing itself properly from the old skin of the last hopper instar, because in the case of the female part of the old integument was still adhering to the teeth of the distal incisor lobe and to the maxillary palpi. In the male there was no trace of the old integument adhering to the adult, but it is quite possible that the locust may have freed itself from the old integument after the mandible had been twisted. This twisting must have taken place immediately after the splitting of the old integument before the integument of the adult had hardened.

Dreyer (1937) suggests that an abnormality of the wings of *Locustana pardalina* is due to an alteration in the genetic constitution and that this alteration caused a decreased resistance to bacterial attack (sp. *Micrococcus*). He states of the locusts which had crumpled wings: "They remind one strongly of similarly localized (and similarly produced?) abnormalities in *Drosophila*, and we may legitimately assume that the abnormality will be hereditary." From my experience on the breeding of locusts in captivity, I think that Dreyer has misinterpreted the occurrence of crumpled wings in locusts. They, like the mandibles described above, are accidental and are due to injury at the time of moulting. The locusts which I have found with crumpled wings were always due to (1) the tip of the wing rudiments of the hopper being damaged and when the blood (or haemolymph) was pumped into the veins of adult wings it escaped and the resulting pressure was insufficient to expand the wings, or (2) the last moult taking place on the floor of the cage instead of on a twig or support. Locusts which moulted on the ground were rarely able to expand the wings properly. I have bred from locusts with crumpled wings and found the succeeding generations were normal, which shows that it is not an hereditary character, as suggested by Dreyer.

REFERENCES.

DREYER, T. F., 1937, Wing abnormality in *Locustana pardalina*.—*Nature*, **139** : 197.

HAMILTON, A. G., 1936, The relation of humidity and temperature to the development of three species of African locusts—*Locusta migratoria migratorioides* (R. & F.), *Schistocerca gregaria* (Forsk.), *Nomadacris septemfasciata* (Serv.).—*Trans. R. ent. Soc. Lond.*, **85** : 1–60, 26 figs., 2 pls.

BOOK NOTICE.

The Pests of Fruits and Hops. By A. M. MASSEE. 8vo. London. Crosby Lockwood & Son, Ltd. (Agricultural and Horticultural Handbooks.) 1937. 15*s.* 0*d.* pp. 294, 26 pls.

This book is stated to be the third of a line including Ormerod, 1898, *Handbook of Insects injurious to Orchard and Bush Fruit*, and Theobald, 1909, *Insect Pests of Fruit.*

Its contents are arranged under the several sorts of fruit and hops grown in this country, and to each fruit, or group of fruits, a chapter is devoted. Additional chapters are concerned with beneficial insects, insecticides, spraying equipment and methods by J. Turnbull, and three indices complete the book.

At the beginning of the chapters is given a list of pests of the fruit concerned, the more important pests being specially indicated. Each pest is then described fully and instructions given on control measures.

The illustrations, which are almost all half-tones, show typical examples of the damage done by pests and figures of the pests causing the damage.

For the benefit of those seeking more specialised information on special points a select list of references is given at the end of the section devoted to each pest.

AQUATIC INSECT LARVAE WHICH OBTAIN OXYGEN FROM THE ROOTS OF PLANTS

By G. C. Varley, M.A., F.R.E.S.

(Research Fellow, Sidney Sussex College, and Department of Zoology, Cambridge.)

Parallel adaptation is a subject of perpetual interest to zoologists, and the insects discussed in this paper provide striking examples of this phenomenon. For many years it has been known that the larvae of the beetle *Donacia* pierce plant roots and get oxygen from the intercellular air spaces, and more recently other examples of this habit have come to light. It is known to occur in the larvae of the Rice Water-weevil, *Lissorhaptrus*, in the puparia of two genera of Ephydrid flies, in certain Culicid larvae and pupae, and in the larvae of the Syrphid fly *Chrysogaster.*

It is the purpose of this paper to describe the larva and puparium of *Chrysogaster hirtella*, and to describe in more detail than hitherto the respiratory mechanism of the puparium of the Ephydrid fly *Notiphila riparia.* Both these insects were discovered with the larvae and cocoons of *Donacia* on the roots of the grass *Glyceria aquatica* Sm. which fringes the river Cam just south of Cambridge (Varley, 1935). The *Glyceria*, which was growing in about a foot of water, was uprooted and the adherent mud was washed from the roots through a net. The puparia of *Notiphila* were found firmly fixed to the roots, and the larvae of *Chrysogaster* were sometimes found fixed to the roots, but were more often washed off into the net.

Chrysogaster hirtella Loew.

The larva of *C. hirtella* has not been described before, but Beling (1888) gave a verbal description of the larva of *C. viduata*, and Verrall (1901) also recorded this latter species and *C. metallica* as inhabitants of mud. It is clear from Beling's brief account that his larva was very like that of *C. hirtella*, but he makes no mention of the function of the needle-like hind spiracles.

The last-instar larva (fig. 1, A) is about 7 mm. long, flattened on the ventral side and tapering towards the hind end. It is dull grey in colour and slightly transparent. The integument is covered with rows of branched hairs which are longer near the hind end of the body. The head is small, and when it is not retracted the short two-jointed antennae can be seen. The pharynx has eight longitudinal grooves with fringes of bristles exactly as described for *Eristalis* by Miall (1903). The first five abdominal segments bear prolegs on the ventral side which are reminiscent of those of *Eristalis*, but they are armed only with a few weak hairs instead of hooks. The anus is a transverse slit on the ventral side of the apparent eighth abdominal segment. On either side of this segment are two small lobes covered with long branched hairs. Behind the last of these lobes the body narrows off into a telescopic process at the end of which are the hind spiracles. This process can be extended to a length a little greater than half the length of the rest of the body.

The tracheal system (fig. 1, B) consists of two thick longitudinal trunks joining the vestigial anterior spiracles with the hind spiracles; the connection is not complete since the trachea is occluded a short distance before reaching

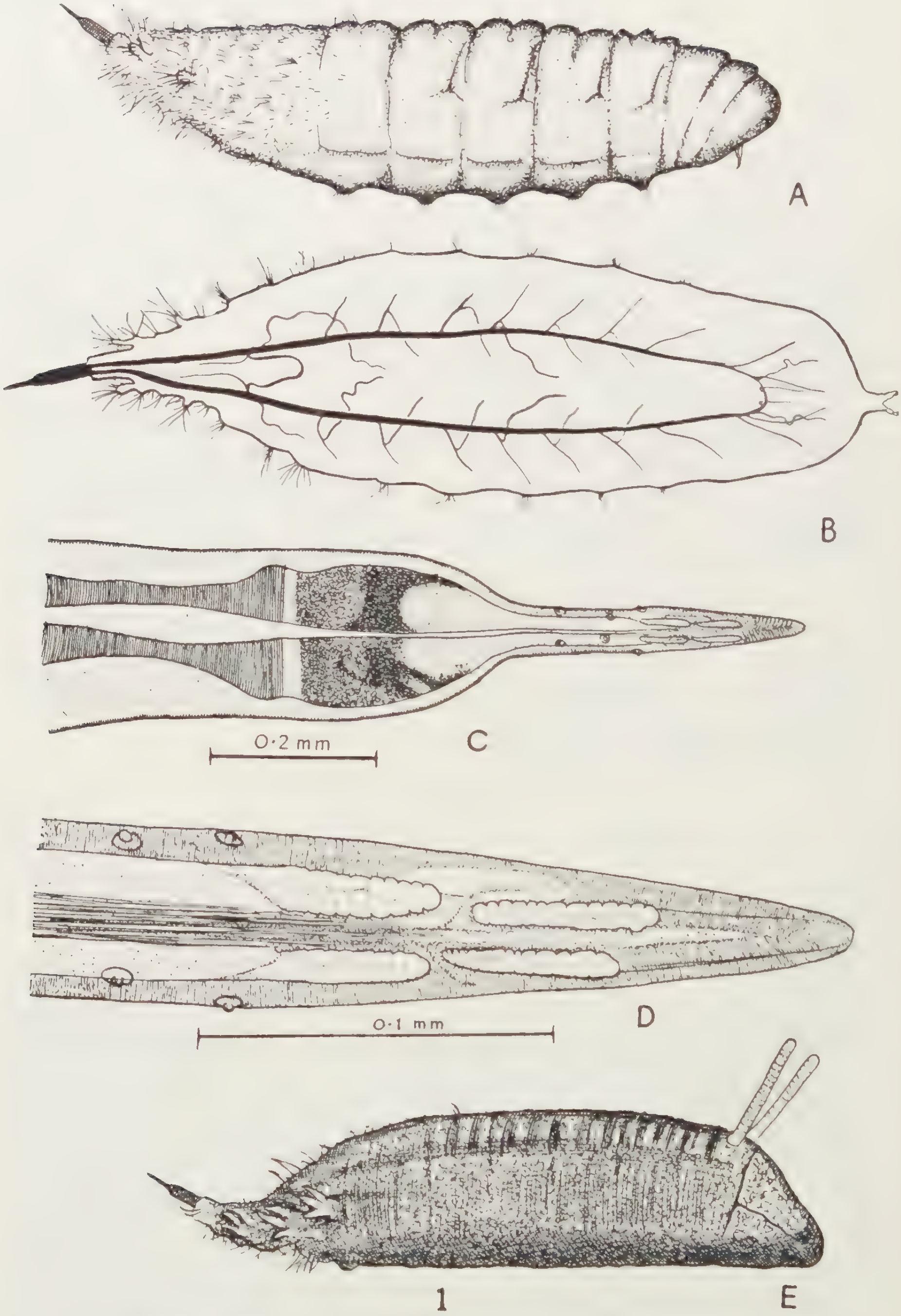


Fig. 1.—*Chrysogaster hirtella.* A, fully-grown larva of *Chrysogaster hirtella* ; B, tracheal system of same ; C, hind spiracles of same ; D, tip of needle with spiracular apertures ; E, puparium.

the non-functional anterior spiracles. Anterior and posterior commissures join the main trunks, and from the anterior commissure arise three pairs of tracheae which pass into the head; eight pairs of branched tracheae come off the longitudinal trunks between the two commissures. The tracheal trunks are constricted before the felt chambers of the hind spiracles. The hind spiracles (fig. 1, C) open on a needle-like point 0·3 mm. long and 0·05 mm. in diameter which is carried on a sclerotised cylindrical base in which lie the two felt chambers of the spiracles. The apical half of the needle tapers regularly and ends in a rounded point 0·02 mm. in diameter, and on the tapering part open three pairs of spiracular apertures, each of which is about 0·05 mm. long and 0·01 mm. across with its long axis parallel to the axis of the needle. Two pairs of these openings are on the dorsal side, one behind the other and the third pair is on the ventral side : one of the latter can be seen faintly indicated in fig. 1, D, being seen by transparency. On the base of the needle are three pairs of small sensilli, each of which is a small round peg 0·003 mm. across set in a small circle. No trace of a stigmatic scar could be found.

There is no doubt that the modified spiracle penetrates into the roots of the grass, though only one larva was actually found with the needle *in situ*. An examination of the roots showed that they were about 1·2 mm. in diameter, and that they had air spaces within 0·05 mm. of the outside. The needle of *Chrysogaster* is amply long enough to reach this source of oxygen, and is so sharp that a very small force indeed will push it into a root.

The food of the larva is unknown, since the guts of those dissected in the winter were quite empty. The fact that the structure of the pharynx is so like that of *Eristalis* suggests that it too is a filter feeder, and eats only very small particles.

In captivity the larvae pupated in due course on the surface of the damp sand in which they were kept. No puparia were found in the field, but the puparium of *C. macquarti* was found by Beling (1888) in flood refuse, and is probably normally formed amongst the vegetation at the edge of the water, as is that of *C. pulchella* (Johannsen, 1935). The puparium (fig. 1, E) resembles the larva, except that the body is more plump, and bears large prothoracic pupal spiracles which protrude from the dorsal side of the first abdominal segment, as is the rule in these Diptera. The adult flies emerged in June. Owing to lack of time no serious attempt was made to find the eggs or the first- and second-instar larvae.

Notiphila riparia.

The larva of *Notiphila riparia* has not been seen by me, but the puparia are sometimes to be found in large numbers on the roots of the *Glyceria*, all firmly attached by the hind spiracles. Since this attachment must be made by the last-instar larva before the puparium is formed, it would seem likely that the larva also gets its oxygen from the roots in the same way. However, Grünberg (1910 : 259, 278) states that the larvae of *Notiphila* and *Hydrellia* feed on the leaves of water plants and only attach themselves to the roots just prior to pupation. Keilin (1915) figures the hind spiracles of *Hydrellia modesta*, which are very similar to those of the puparium of *Notiphila riparia*, but they are not described in any detail.

The puparium of *Notiphila riparia* is illustrated in fig. 2, A, where it is seen that the hind end of the body bears a pair of sharp spines inserted on a small rounded knob. These spines are shown in more detail in fig. 2, B, C, D.

Each is 0·28 mm. long, very sharp, and strongly sclerotised. The spiracular apertures are on the apical half of the spine, and only two of the three can be seen in the figure. Detail of the structure of the end of one of the apertures drawn under an oil immersion lens is shown in fig. 2, D. The opening is crossed by a series of trabeculae, which probably lie in a transparent membrane, which is only pierced by a very narrow slit. This structure is assumed by analogy with the spiracles of other Acalyptrate Diptera which I have studied. The spines are certainly quite long enough to reach into the intercellular spaces of the plant. However, they are not likely to be connected directly with the spiracles of the pupa within the puparium since it is the rule in many Diptera that the pupa has spiracles only on its prothorax. Probably the respiratory exchange takes place by diffusion through the space between the pupa and the puparium from the root to the prothoracic spiracles.

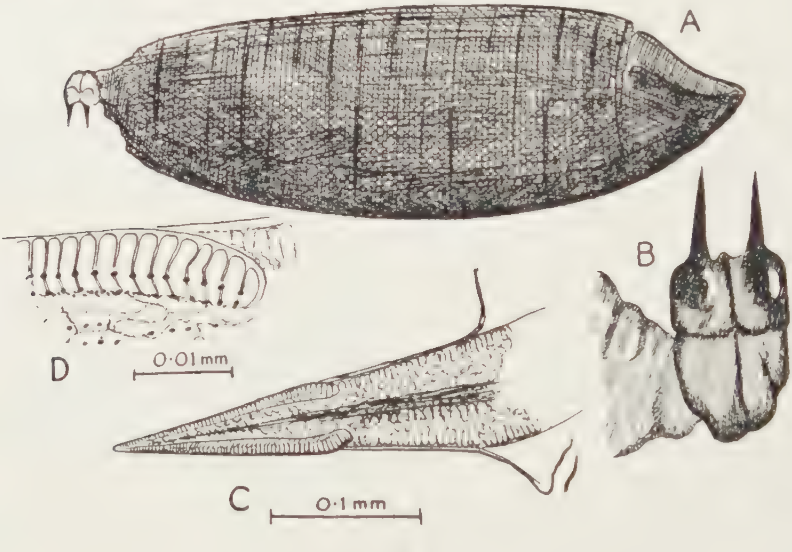


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Fig. 2.—*Notiphila riparia.* A, puparium of *Notiphila riparia*; B, spiracular spines of same; C, hind spiracle, showing two of the three apertures; D, detail of the end of a spiracular aperture.

Discussion.

All of the insects known to pierce plant roots to obtain oxygen live in mud with the exception of the mosquitoes. It is well known that in mud the bacterial decay of organic matter removes almost all the free oxygen, so that animals which live in this environment must get oxygen by special methods. The rat-tailed larvae of the Syrphid fly *Eristalis* reach atmospheric air with their extremely long telescopic respiratory siphons, and it is another modification of this " tail " which enables *Chrysogaster* to pierce the roots of *Glyceria*. *Chrysogaster* is alone amongst these mud-dwellers in having the spiracles opening upon a single needle. The larvae and hence the puparia of the Ephydrid genera *Hydrellia* (Grünberg, 1910 : 278, and Keilin, 1915) and *Notiphila*

(Grünberg, 1910 : 259) have the spiracles opening on two very sharp spines at the end of the body, and these anchor the puparia to the roots, and presumably provide a supply of oxygen also. In the larvae of the beetles *Donacia* (CHRYSOMELIDAE) and *Lissorhaptrus* (CURCULIONIDAE) the structure of the piercing organs is more complex. In *Donacia* (Böving, 1910) there are two movable spines formed by the hind spiracles which act together like the two parallel mouth-hooks of a predaceous Anthomyiid larva, while in *Lissorhaptrus* (Isely and Schwardt, 1930, 1934, and Böving and Craighead, 1931) there are six pairs of spiracular spines on the dorsal side of the body, and the spines of each pair act together like a pair of sharp mandibles. This species is found feeding upon the roots of rice, which grows in shallow water, and the roots of the rice will be the only source of oxygen available. It is believed by Isely and Schwardt that the larvae pierce the roots with these sharp spiracles. The spiracles of both *Donacia* and *Lissorhaptrus* are of the special biforous type which has been termed bicameral, and in these genera the chambers of the spiracles extend right up the spine. Unfortunately there is some difference of opinion as to the interpretation of the structure of such spiracles. Careful examination of the spiracles of *Donacia* shows what are apparently two narrow slits along the length of the spine which appear to open into the chambers, and Böving and Craighead figure a section of this spiracle which shows what may be this slit, but according to them it is not open, and the true opening is an irregular hole leading directly into the atrium at the base of the spine. In my opinion this interpretation is not likely to be the correct one, and I prefer to think that the slits are actually open, and that the larva can therefore have its tracheal system in direct contact with the air spaces of the plant. The irregular hole described by Böving as the actual aperture is in reality the stigmatic scar, which is a morphological necessity in any spiracle which has more than a single opening.

The only other insects to be considered are the larvae and pupae of certain mosquitoes. It is particularly interesting that those species which have evolved a specialised siphon in the larva which pierces the plant root, have also evolved specialised respiratory trumpets in the pupal stage which are used in much the same way. These mosquitoes belong to the genera *Taeniorhynchus* and *Ficalbia*, and for detailed descriptions the following authors should be consulted : Howard, Dyar, and Knab (1912), Hopkins (1936), Wesenberg-Lund (1918), Galliard (1934), Bonne-Wepster (1932), and Iyengar (1935). Hopkins and Iyengar both point out that the Indian species of mosquito with this habit all seem to be connected with the water plant *Pistia stratiotes*, and Iyengar states that some at least of the species lay their eggs on the leaves of this plant, and that both larvae and pupae later get their oxygen from its roots, which hang in the water. What particular advantage these mosquitoes possess over the species which come to the water surface for their oxygen does not seem at all clear, but nevertheless the morphological adaptations are very complex.

There can be no doubt that this habit and the correlated structural modifications of the spiracles have originated independently in the two families of Coleoptera and in the three families of Diptera, because the piercing organs are quite distinct in location or structure in each case. At present no intermediate forms have come to light to suggest how the changes have been accomplished in mud-dwelling insects, but in the mosquitoes intermediate stages in the acquisition of the habit are already known. Hopkins (1936) states that the larvae of *Aediomyia* put their siphons into gas bubbles beneath the leaves of water plants and even try to fix their siphons into the plant tissues, though the siphons are not specially modified into piercing organs. Certain species of *Ficalbia* (but not all) have a rather simple piercing siphon, and the species of *Taeniorhynchus* have a more complex siphon which has movable hooks that anchor the larvae in position on the roots.

It is hoped that this paper will focus attention on these insects whose habits are of such great interest, and about which so little is known. It is almost certain that search in suitable localities will bring new examples to light, and richly repay the effort expended.

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DEVELOPMENT OF THE FEMALE GENITAL DUCTS IN *ZYGAENA* (LEPIDOPTERA)

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Communicated by O. W. RICHARDS, M.A., D.Sc., F.R.E.S.

TECHNIQUE.

THE pupae which had been preserved for some time in alcohol were subjected to the Diaphanol process for chitin-softening which has been described in a previous paper on Trichoptera (Dodson, 1935). The chief problem to be faced when sectioning lepidopterous pupae is the disposal of the mass of crystalline urates which are stored in the body. This problem does not exist in the Trichoptera, as the animals pupate in running water and easily dispose of all waste products.

In *Zygaena* the urates exist as a hard white mass in the fat body, lying dorsal to the gut in the region of the fifth and sixth segments. Unsatisfactory attempts were made to dissolve the urates directly, and finally piperazine was used. This is an organic substance which makes a water-soluble compound with uric acid. The pupal abdomen was first soaked for one hour in acid alcohol in order to convert all urates to uric acid, the abdomen was then placed in an aqueous solution of piperazine. The latter must not be too concentrated, about half a gramme dissolved in 4–5 c.c. of water makes a solution of the right strength; if appreciably stronger the insect abdomen will swell up and burst. The abdomen was left in the piperazine for twelve hours and then transferred to distilled water for another twelve, after this it was dehydrated and embedded in celloidin and wax, all the urates having been removed.

Transverse sections were cut from segment five posteriorly, and lateral reconstructions were made from the series.

Zygaena belongs to those Lepidoptera which have two genital openings in the female, but is otherwise rather primitive as regards its genitalia (Hewer, 1934). As in all Lepidoptera with two genital openings, the bursal one is on the eighth segment and the oviducal on the ninth. It has been shown in *Brachycentrus* (Trichoptera) that there is a single genital opening on the eighth segment, and this condition Petersen (1889) believed to be the primitive one for Lepidoptera. Some of Petersen's evidence, however, has been disputed, and he bases his views to a considerable extent on the work of Jackson (1889), who studied the development of the genital ducts in *Vanessa io*. As *Vanessa* is a rather specialised genus it was decided to study development in a more primitive type.

The bursal opening of *Zygaena* is on the anterior part of the eighth segment, the oviducal on the ninth very close to the anus. The bursa is connected with the common oviduct through the ductus seminalis which leaves the bursal duct very near its opening to the exterior. This is a primitive feature, as in the more advanced types the ductus seminalis is connected higher up the bursal duct or else leads from the bursa itself (Petersen and others).

Zygaena is peculiar in having a pseudo-bursa or bulla which is really a swelling on the ductus seminalis.

Description of Stages.

Pupa Stage I (fig. 1).

This pupa was the one in which the genital ducts were the least developed of all. Unfortunately the delimitation of the segments was not very clear, but careful scrutiny and comparisons with other series enabled it to be estimated fairly accurately.

The paired oviducts leading from the ovarioles (four on each side) join in the seventh segment. From their junction a sac-like projection extends backwards for a short distance ending blindly near the ventral ectoderm. This backward projection of the fused oviducts is the rudiment of the front end of the common oviduct.

According to Jackson, the hinder end of the common oviduct of *Vanessa* is formed from a median ventral longitudinal groove in the ectoderm which closes ventrally except over the bursal aperture. In *Zygaena* the hinder end of the common oviduct is definitely formed from an ectodermal inpushing and the rudiment is shown in fig. 1 (m.c.od. p.c.od). This may have been formed from a groove such as described by Jackson, although the stage in which the groove is still open has not been seen.

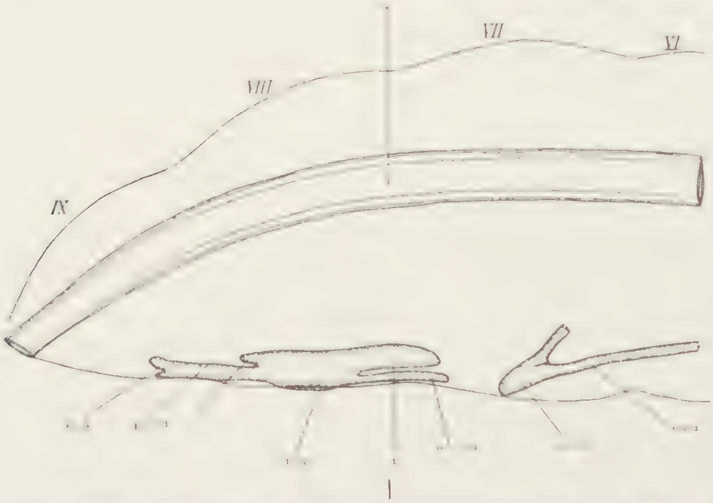

Fig. 1.—ac.gl. accessory glands; a.c.od. anterior common oviduct; b. bursa; b.ap. bursal aperture; m.c.od. middle common oviduct; p.c.od. posterior common oviduct; r.s. receptaculum seminis; r.od. right oviduct.

The bursa and spermatheca or receptaculum seminis, according to Jackson, arise as paired structures which secondarily join the common oviduct and then lose their paired character. This may be true for *Vanessa*, but in *Zygaena* no paired or bilobed appearance of these structures has been seen.

The paired oviducts as in all insects are undoubtedly mesodermal and the median common oviduct ectodermal in origin. In the Trichoptera the transition between ectoderm and mesoderm is quite clearly defined, because the paired oviducts end in the young pupa in ampullae embedded in the ectoderm and the ectodermal structures are developed posteriorly to the ampullae, but in *Zygaena* the exact place at which mesoderm ends and ectoderm begins is not so clear.

Pupa Stage II (fig. 2).

The bursa has greatly increased in size growing in an antero-dorsal direction, the entire ectodermal rudiment comprising the bursa, spermatheca and accessory glands, some of which in stage I are situated behind the bursal aperture, have been pulled forwards and upwards by the growth of the bursa, so that they now lie in front of the aperture. This rapid growth and inpushing of the ectodermal rudiment is found also in Trichoptera, and at any stage during the development a temporary re-arrangement of the positions of the various structures is likely to occur. Thus the exact position of any organ during later development is not necessarily of any particular significance, but may simply be due to a mechanical effect of the rapidly growing ectoderm.

The two rudiments of the common oviduct have now joined into a single duct which extends as far back as the eighth segment where it opens to the exterior. Behind this opening the dorsal wall of the oviduct is continuous with a sheet of thickened ectoderm running on to the ninth segment. This thickened ectoderm will form that part of the common oviduct which in the adult is posterior to the bursal aperture. In practically all insects which have an unpaired oviduct the posterior part is formed by the ventral closure of a median longitudinal groove in the thickened ectoderm, *e.g.* Coleoptera, Orthoptera, Dermaptera, Diptera. This formation has not been observed in *Zygaena*, but a stage in which the oviduct was an open groove was found in *Brachycentrus* of the Trichoptera, but only after some difficulty; the conclusion then reached was that the groove formation was rather rapid and the groove open for a short period only. Jackson has, moreover, observed the groove in *Vanessa*, and it is therefore fairly safe to say that the oviduct in *Zygaena* becomes a hollow tube by the closure of a groove. The only alternative would be a longitudinal split in the thickened ectoderm similar to that observed in the front end of the oviduct in Trichoptera.

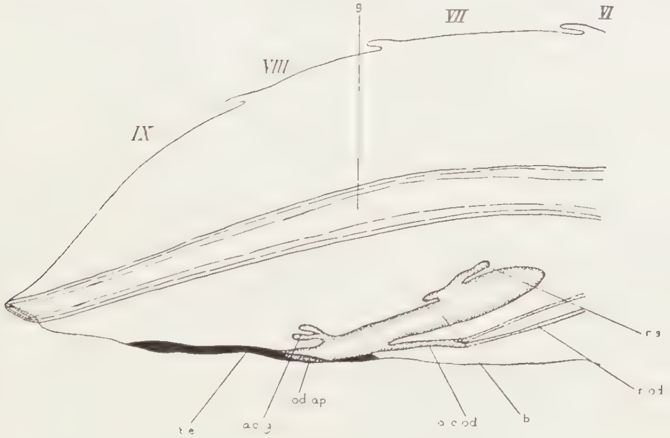

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Fig. 2.—ac.gl. accessory glands; a.c.od. anterior common oviduct; b. bursa; od.ap. oviducal aperture; r.od. right oviduct; r.s. receptaculum seminis; t.e. thickened ectoderm.

The future bursa is shown in fig. 2 as a large forwardly directed dorsal projection of the common oviduct at the end of the seventh segment. On the dorsal side of the bursa near the base is another smaller projection, the rudiment of the receptaculum seminis or spermatheca. Posterior to this there is another small, dorsal outgrowth consisting of a stalk and paired lobes which represent the accessory glands and their common duct.

Pupa Stage III (fig. 3).

The connection between bursa and oviduct is becoming restricted by a longitudinal slit and the hollow mass of ectoderm is becoming differentiated into bursa, oviduct and ductus bursae. The axes of bursa, oviduct and receptaculum are indicated in the diagram. The axis of the bursa, it will be noted, crosses that of the oviduct and ends ventrally at the opening on the eighth. Thus the bursa is gradually losing its direct dorsal connection with the oviduct. The receptaculum, on the other hand, retains the position it will occupy in the adult and still leads dorsally into the oviduct. The relative positions of the receptaculum and bursa remain unchanged; and both are still median dorsal outgrowths of the main ectodermal mass, the receptaculum being posterior to the bursa. Growth and enlargement has taken place over the whole ectodermal rudiment and the oviduct is somewhat thicker anteriorly.

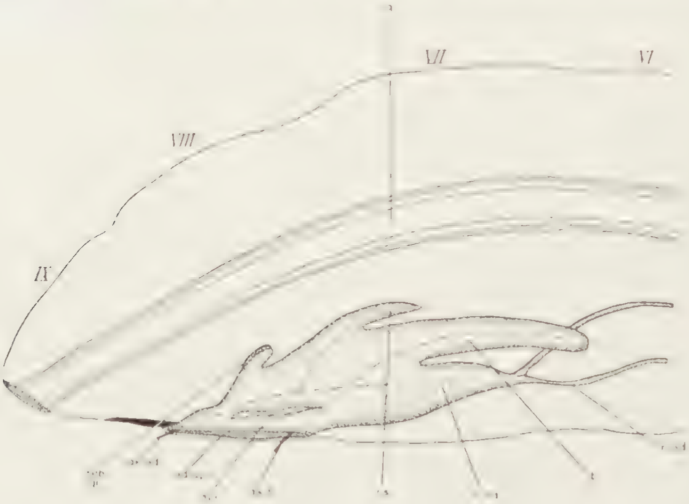

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Fig. 3.—ax.b. axis of the bursa; ax.od. axis of the oviduct; b. bursa; c.od. common oviduct; r.od. right oviduct; r.s. receptaculum seminis; seb.gl. sebaceous glands; spl. split; od.ap. oviducal aperture.

Pupa Stage IV (fig. 4).

The ductus seminalis, which in the adult is the only connection between the bursa and oviduct, is not yet formed; bursa and oviduct are still directly connected. Just above this connection there is a small outgrowth (o.g.), this almost certainly represents the future bulla which in the adult is a swelling on the ductus seminalis. The ductus bursae will be formed from the area surrounding the bulla and the direct connection between bursa and oviduct. This area will be constricted into a narrow tube connecting the oviduct and receptaculum on the one hand with the bursa and bursal opening on the other.

The receptaculum seminis has increased considerably in length and is becoming coiled, it joins the common oviduct at the same spot as the latter is connected with the bursa.

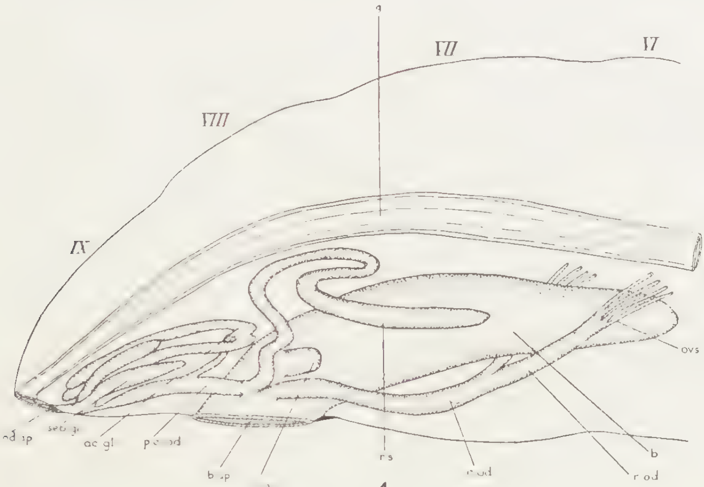

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Fig. 4.—ac.gl. accessory glands; b. bursa; b.ap. bursal aperture; c.od. common oviduct; od.ap. oviducal aperture; o.g. outgrowth; ovs. ovarioles; p.c.od. posterior common oviduct; r.od. right oviduct; r.s. receptaculum seminis; seb.gl. sebaceous glands.

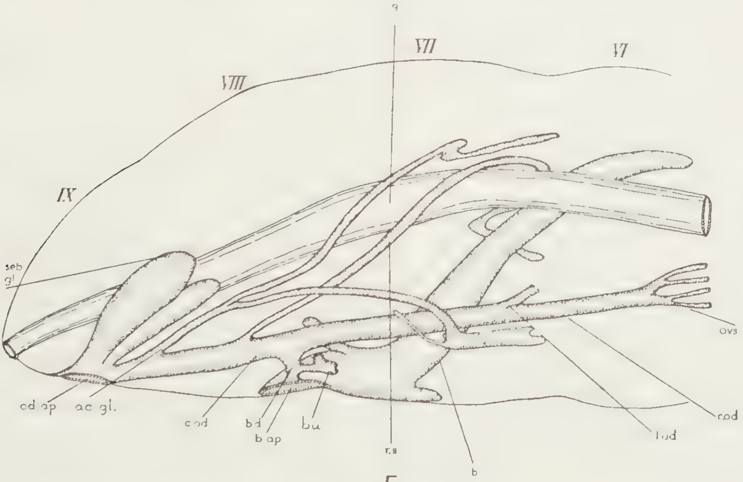

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Fig. 5.—ac.gl. accessory glands; b. bursa; bu. bulla; b.ap. bursal aperture; b.d. bursal duct; c.od. common oviduct; l.od. left oviduct; od.ap. oviducal aperture; ovs. ovarioles; r.od. right oviduct; r.s. receptaculum seminis; seb. gl. sebaceous glands.

The accessory glands have also increased in length and point backwards, which is curious, as in the succeeding pupal stages and adult they are anteriorly directed.

A second pair of glands have also appeared, these are the odoriferous glands which lead dorsally into the common oviduct close to its opening on the ninth segment. These glands are stated by Jackson to arise in *Vanessa* as paired independent invaginations on the ninth sternite which later acquire a connection with the oviduct.

Pupa Stage V (fig. 5).

This stage is remarkable for the elaboration of the ductus seminalis now fully formed and leading from the bursal aperture into the oviduct, the direct connection between bursa and oviduct shown in all previous stages having now been lost. The bulla, which was visible in the previous stage as a small outgrowth on that part of the bursal mass which was going to form the ductus seminalis, is now showing clearly as a swelling on the seminal duct.

The bursa is still growing in an antero-dorsal direction and has some folds and convolutions at the base. These are probably forerunners of the pockets on the shoulders of the adult ductus bursae (Hewer, 1934). In addition, a swollen anterior end will later give rise to both the bursa proper and to a comparatively slender posterior part known as the bursal duct.

The receptaculum seminis, accessory and odoriferous glands have similarly increased in size but have not altered their points of junction with the oviduct to any extent.

The genitalia now conform to the adult plan, although further differentiation naturally takes place. The bursal mass forms the bursa proper and ductus bursae and the seminal duct increases in length. The eighth and ninth segments also become considerably shorter in the adult.

DISCUSSION.

The investigation of *Zygaena* is intended less to verify the work of Jackson on *Vanessa* than to correlate the development of a more primitive type of the Lepidoptera with that of the Trichoptera.

According to Jackson the bursa and spermatheca arise as paired ectodermal pockets in the eighth segment, dorsal to the oviduct. If the bursa and spermatheca ever have a paired origin in *Zygaena* it is in a different stage to any yet observed.

Pupal Stage II bears a striking resemblance to the adult Trichopteran condition, viz. the common oviduct opening on the eighth (with only a backward extension of thickened ectoderm on the ninth) and bearing on its dorsal surface a pair of glands and two unpaired tubular projections. It has been shown from the subsequent development that the more posterior of these projections becomes the receptaculum, the more anterior the bursa, while in Trichoptera the anterior projection forms the spermatheca and the posterior the bursa. This serves to confirm the opinion expressed previously that the Trichopteran " bursa " really corresponds to the receptaculum in Lepidoptera and the Lepidopteran bursa is derived from the Trichopteran spermatheca. The names in the Trichoptera were given, as far as can be ascertained from the literature, with no evidence for the functions or origins of the organs concerned.

The formation of the oviduct in *Zygaena* is similar to that in the Trichoptera, but in the latter the oviduct is formed from two ectodermal rudiments and in the former from three. The hindermost portion of the oviduct between the bursal aperture on the eighth and the oviducal on the ninth is absent in *Brachycentrus* (Trichoptera), there being a single genital aperture on the eighth segment.

In *Brachycentrus* the front portion of the oviduct is formed from the backward growth and fusion of a pair of ectodermal ducts; in *Zygaena* the formation of the front part appears to be partly from the backward growth of an ectodermal rudiment from the junction of the mesodermal ducts and partly from the forward growth of the *middle* oviducal rudiment.

The hinder section of the oviduct in *Brachycentrus* is homologous with the middle rudiment in *Zygaena* and both are formed from an unpaired ectodermal inpushing.

The hindermost portion of the oviduct in *Zygaena*, *i.e.* that part which runs from the bursal aperture on the eighth to the oviducal on the ninth segment, is the last to be formed and has no representative structure in Trichoptera.

The stages in the formation of the oviduct in *Brachycentrus* and *Zygaena* show a well-marked evolutionary progression. The *Brachycentrus* larva actually shows a condition like the EPHEMERIDAE, in which the mesodermal oviducts end in ampullae in the ectoderm of the seventh segment, but this stage has been eliminated in the development of the Lepidoptera.

The primitive median oviduct was presumably formed by the approximation and fusion of lateral ectodermal ducts which were continuous with the mesodermal oviducts. This primitive oviduct probably opened on the seventh segment, the eggs, when laid, passed back along an open groove to the eighth segment, this groove later closed to form the hindermost section of the common oviduct in Trichoptera and the middle section in Lepidoptera. The stage in which part of the oviduct is an open groove has been observed in Trichoptera but not in *Zygaena*. There is no reason to suppose that Jackson's evidence is to be doubted on this point. The backward extension of the oviduct from the eighth to the ninth segment was developed subsequently in the Lepidoptera but not in Trichoptera.

The developmental evidence indicates that the bursal aperture in Lepidoptera represents the primitive oviducal aperture that is still present in Trichoptera. A similar conclusion was reached by Petersen, who did not work with the Trichoptera but made an exhaustive examination of all the families of Lepidoptera. He gave it as his opinion that the bursal aperture corresponded to the single primitive genital aperture and that the backward extension of the oviduct on to the ninth was a later addition. Petersen stated that in the MICROPTERYGIDAE and HEPIALIDAE, which have a single opening, this opening was on the eighth, but unfortunately it has since been proved by Philpott, Norris and others that the opening in MICROPTERYGIDAE is on the ninth; the case of the HEPIALIDAE is still in doubt. The developmental evidence of Jackson on which Petersen partly bases his views is probably a sounder support than his own morphological investigations of the so-called primitive types, which although primitive in other respects do not appear to be so in the matter of the female genital opening.

In the families of Lepidoptera in which there is only one aperture it is an open question exactly how primitive the genitalia really are. It seems unlikely that the more primitive families have had two openings and lost one, and the probability is that although less specialised than the rest of Lepidoptera, they have progressed a little further than *Brachycentrus* by a simple backward extension of the oviduct on to the ninth segment, no bursal aperture being left. The backward extension of the oviduct in which the original opening is retained as a copulatory aperture is characteristic of the more specialised Lepidoptera, but the simple backward extension of the oviduct in which the primary opening is not retained is commonly met with in many groups of insects, occurring frequently and independently.

My thanks are due to Professor J. W. Munro and Dr. A. D. Imms, F.R.S., for much valuable advice and to Mr. H. R. Hewer for advice, criticism, assistance in technique and collecting material.

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NOTES ON THE INSECT-FOOD OF THE LITTLE OWL

By Miss A. Hibbert-Ware.

Communicated by Sir Edward Poulton, F.R.S., F.R.E.S.

I. *Forficula auricularia* L.

Several points of interest have arisen during the inquiry into the nature of the food of the Little Owl in connection with the Common Earwig.

1. When they are found in large numbers in single pellets, how have they been obtained by the bird? The pincers are usually contained in a matrix of soil or dung, hence the insects do not appear to have been taken whilst on the wing. Do earwigs swarm in vast hordes on the surface of the ground by night?

2. The pellets often contain large numbers of earwigs of one sex. This is explained in late winter and spring by the females being in hiding with their eggs, but why should there be separation of the sexes at other times of year? Examples are :—

40 earwigs in 1 pellet, all males : 13th May, Longstanton.
19 earwigs in 2 pellets, all females : 11th June, Seaford.
11 earwigs in 2 pellets, 10 females : 15th June, Seaford.
108 earwigs in gizzard, chiefly males : 3rd Oct., N. Wales.

(Prof. Newstead examined this gizzard and remarked on the predominance of males.)

3. Another point of interest is that, at Longstanton and Girton (Cambs.) and Brandon (Suffolk), almost all the earwigs have been the long-pincered variety of *F. auricularia* L. From other districts this variety has occurred sparsely.

II. Coleoptera.

Among the most numerous Coleoptera hitherto identified in the pellets and other food material are :—

Carabus violaceus L., *C. nemoralis* Müll., *Nebria brevicollis* F., *Harpalus aeneus* F., *Pterostichus madidus* F., *P. vulgaris* L., *Abax ater* Vill., *Staphylinus olens* Müll., *S. aeneocephalus* De G., *Byrrhus pilula* L., *Aphodius punctato-sulcatus* Sturm., *Geotrupes typhoeus* L., *G. stercorarius* L., *Melolontha vulgaris* F., *Agriotes obscurus* L., *Lacon murinus* L., *Otiorrhynchus clavipes* Bons., *Sitona humeralis* Steph., *Phytonomus punctatus* F., *Barynotus obscurus* F.

THE PROCRYPTIC APPEARANCE IN TWO RESTING ATTITUDES OF THE GEOMETRID MOTH *FIDONIA PLUMMISTARIA* VILL. (= *PLUMISTARIA* BKH.) OBSERVED BY LT.-COL. H. D. PEILE AT MENTONE, S. FRANCE

By Sir EDWARD POULTON, F.R.S., F.R.E.S.

THE " nature-prints " exhibited to the Meeting were sent by my friend Col. Peile with the following notes written on 19 Feb. 1937 :—

" I do not think I have before mentioned to you what seems to me a very interesting detail about the common moth *Fidonia plummistaria*. The upperside of fore-wing and underside of hind-wing being protectively marked to blend with pine-bark, needles and stones when the fore-wings are thrown back over the hind-wings—the moth being common among pine-trees at about 600 ft. elevation."

It is interesting that this moth should possess a procryptic pattern, on the exposed under surface of the wings when held upright over the back, like that so commonly found in butterflies. In this attitude the projecting apical area of the fore-wing under surface resembles that of the hind-wing, forming with it one continuous pattern. This is, I believe, the appearance adopted for protection during feeding and short rests between flights. In these conditions a similar attitude, associated with a sober, inconspicuous under surface, is commonly assumed by Geometrid moths, but the detailed procryptic pattern of this *Fidonia* is, I believe, rare : indeed, I do not remember having noticed it before in a moth.

During prolonged rest the hind-wings are evidently covered by the fore, while the procryptic upper surfaces of the latter become nearly continuous along the mid-dorsal line, producing the effect of a single triangular patch on the bark or other surface selected by the moth.

Col. Peile informs me that he also had inferred that the peculiar distribution of the procryptic pattern is utilised in the manner described above. Mr. L. B. Prout, who had kindly confirmed the identification, also agreed with the interpretation and believed that the display of a similar detailed concealing pattern by the upper surface in one position and the under in an entirely different one, was rare, although common with the aposematic coloration of distasteful Lepidoptera.

Mr. J. A. Simes has suggested, on seeing the specimens, that the moth probably rests on slender twigs or branches, when the under surface would be visible on an approach from one direction and the upper from another. In such resting positions the attitude making " a single triangular patch " would utilise the procryptic pattern of the under as well as the upper surface.

NOTES ON *HYPOLIMNAS BOLINA* L., AND THE FOOD-PREFERENCES OF THE GIANT TOAD (*BUFO MARINUS* L.), IN SUVA, FIJI

By HUBERT W. SIMMONDS, O.B.E., F.R.E.S.

[Communicated by Sir EDWARD POULTON, who said that the following extract from his friend's letter was written from Suva on 7 Jan. 1937, and that it was very interesting to hear of the increased numbers of the male *bolina* ; also that he hoped the toad would be tested with a variety of Fijian butterflies and other insects.]

You will, I know, be interested to learn that male *Hypolimnas bolina* L., are more numerous than I have previously observed in Suva. One male has haunted my garden-gate for seven weeks, presumably the same one. I doubt if females live so long. The giant toad *Bufo marinus* recently introduced into Fiji is interesting. Records show it to be a great eater of millepedes, but a pair I have in the laboratory, when given the common red species, eagerly took it, but then spat it out and have refused them consistently ever since. For so omnivorous a feeder this seems remarkable. I want to try them with certain other things. They simply love woodlice.

MIMETIC AND OTHER ASSOCIATIONS BETWEEN NEOTROPICAL INSECTS AND SPIDERS

By Dr. J. G. Myers, D.Sc., F.R.E.S.

[Communicated by Sir Edward Poulton, who has added the determinations, notes, etc., in square brackets, to the author's records. The remarkable hind-wing development of **No. 4286,** *Trochophora duckei,* investigated and compared with that of other species by Dr. B. M. Hobby, is described in the following communication. In preparing these statements very kind help was rendered by the following friends :—Mr. R. B. Benson, Dr. W. S. Bristowe, Mr. G. E. Bryant, Mr. W. E. China, Mr. H. St. J. K. Donisthorpe, Dr. R. Hanitsch, Mr. N. D. Riley and Dr. Hugh Scott.]

5939. Caught 30.xii.1935, at light, King Fredk. Wm. Fall, Courontyne River, Brit. Guiana.—No other field data, but strongly resembles certain black and yellow Lycids.

[The Longicorn beetle *Carterica mucronata* Ol. (*cinctipennis* Pascoe)—Lamiinae.]

2088. Extract from journal, 22 July, 1931, La Gonave, Haiti.—Thought I saw a red-winged *Pepsis,* such as is common on the island [La Gonave], flying in usual manner across path. Not quite sure on second glance—flight seemed a little heavy. Thought might be a Scoliid mimicking. Caught it—a moth.

(By an oversight the box in which I pinned it had not been supplied with naphthaline. Ants entered and ate clean off the pins everything—including several flies and a small stick-insect—save two small hard Vespids and this moth which was the only insect left intact.)

[The Syntomid moth *Empyreuma pugione* Linn., ♂. The group to which this Müllerian mimic belongs is well known to be distasteful, and the evidence is, in this instance, exceptionally strong.]

1655. Feb. 1931, Mabaruma, N.W. Distr., Brit. Guiana. –Lepidopterous pupa-case (empty) in open network cocoon, at end of long pedicel on under surface of leaf of *Heliconia Bihai* J. S. Mill.

[No cocoon in the British Museum (Nat. Hist.) collection resembles this remarkable specimen, but it is like, although much smaller than, a yellow network cocoon of a Syntomid moth which I remember was considered by Dr. David Sharp to be the model of the Membracid *Oeda inflata* F. He certainly said that the resemblance was undoubtedly to a cocoon, and this opinion has remained fixed in my memory as held by one whose attitude towards mimicry in general was severely critical. I accepted the comparison, which I still think may be valid, and with this in my mind, wrongly corrected Dr. C. M. Child's English translation of Haase's memoir Pt. II.,* in which *Oeda inflata* is figured " showing its resemblance to the empty pupal case of a butterfly "—the interpretation offered in the original work and one which may be more probable than David Sharp's. Mr. W. E. China has shown a specimen of *Oeda* to Mr. N. D. Riley, who " thinks it is suggestive of the pupa of a Lycaenid butterfly. The pair of short club-shaped processes, at the narrow anterior end of the inflation, bears some likeness to the cremasteral hooks of a Lepidopterous pupa." I am glad that the sight of Dr. Myers's beautiful little cocoon has indirectly led to the discovery and withdrawal of a baseless criticism of which I was guilty forty years ago. E. B. P.].

1479. 15 Dec., 1930, Ocumare de la Costa, Venezuela.—On a large-leaved *Coccoloba* near the road, several large clusters (up to 6 inches long) of a vivid yellow and black *Membracis* sp. and their nymphs, but chiefly adults, forming a striking spectacle. A number of large *Polybia* (later determined by Dr. J. Bequaert as *Gymnopolybia pallidipes* Ol.) walking quietly over them, resting entirely on the backs of the Membracids and lapping up honey-dew from them. The Membracids stayed quiet; yet if one barely touched one of them with the finger, it and the adjacent ones burst into flight, with a loud rattling and crackling against the stiff *Coccoloba* leaves. Also milking the Membracids, was a greyish-black ant of the genus *Cryptocerus.*

[The single *Polybia* is a ♀ and the *Membracis* a species near *humilis* Fowler, ♀ (MEMBRACINAE). The evidence of mutual tolerance and of a beneficial association between the wasps and these Homoptera is very interesting, confirming Belt's account of the relationship between MEMBRACIDAE and ants in his *Naturalist in Nicaragua* (2nd Ed., Lond., 1888 : 227–8).]

D 190. 9 May, 1929, Brit. Guiana.—Ant and spider mimic taken in same netful, beating bushes.

[The ant-model is *Camponotus* (*Myrmacladoecus*) *santae-fidei* Dalla Torre, ☿, or very near to that species, but the National Collection contains only a single worker. Mr. Donisthorpe, however, considers that the subgenus is certain. The spider-mimic is *Erica* sp., ♂ : ATTIDAE. Dr. Bristowe has also informed me that the spider mimicking the ant *Cryptocerus atratus* L. at Kobarima, N.W. Brit. Guiana, and exhibited 6 Nov., 1935 (*Proc. R. ent. Soc. Lond.* **10 :** 70–71), is *Aphantochilus rogersi* O. P.-Cambr. (THOMISIDAE).]

5211. 20 Jun. 1935, N.W. Distr., Brit. Guiana.—Myrmecoid spider, feeding on the large, vivid red larvae of the Thrips, *Actinothrips monochaetus* Hood.

[The spider is *Myrmecium* sp., ♀ : DRASSIDAE.]

1629. Feb. 1931, Nickerie, Surinam. *Ipobracon dolens* Cam., ♂.
2330. Dec. 1931, Trinidad. The Reduviid bug mimicking the *Ipobracon.*

Though these actual specimens were taken in two separate colonies I think it is a case of mimicry, since closely similar if not identical species of *Ipobracon* occur within the range of the Reduviid. When caught, the latter, a ♀, was sucking a fly.

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* Haase, E. (1893) : Untersuchungen über die Mimikry auf Grundlage eines natürlichen Systems der Papilioniden. I. Tl. : Entwurf eines natürlichen Systems der Papilioniden. II. Tl. : Untersuchungen über die Mimikry.—Stuttgart. English translation, *Researches on Mimicry, &c.*, Stuttgart, 1896. Review in *Nature,* **57 :** 1–4, 25–6, 1897. The mistaken " correction " appears on p. 26.

[The bug is *Graptocleptes sanguineiventris* Stål, ♀, a species of HARPACTORINAE.]

4286. 7 Jan., 1934, Rupununi, Brit. Guiana.—*Trochophora duckei* Kon., ♂ (Tenthredinidoidea : ARGIDAE), new to British Museum, where it was identified. Feigned dead when caught. The curious black foliar lateral appendages almost amount to a third pair of wings. In the fresh specimen these are flexible, and movable back and forth like wings. I have no idea of their function.

A NOTE ON THE HIND-WINGS OF A SAWFLY, LEAF-HOPPER AND MOTH

By Dr. B. M. HOBBY, F.R.E.S.

WITH THREE TEXT-FIGURES.

IN wing-flexing insects the anal region of the hind-wing bears two distinct folds dividing the wing into three regions known as the remigium, vannus and jugum. According to R. E. Snodgrass (1935, *Principles of insect morphology*, New York : 226–7) the vannal fold typically occurs between the postcubitus and the first vannal vein (= the first and second anal veins of the Comstock-Needham system), but is not always found in exactly the same situation. In the hind-wings of the TENTHREDINIDAE the vannal fold lies immediately in front of the first anal vein, and the jugal fold between the second and third anal veins. A well-developed jugum is characteristic of the TENTHREDINOIDEA (*cf.* A. D. MacGillivray, 1906, *Proc. U.S. nat. Mus.*, **29** : 569–654), but in the very rare Argid, *Trochophora duckei* Konow (1905, *Z. syst. Hym. Dipt.*, **5** : 158–9), the only known representative of the genus, this region is expanded in an extraordinary degree. As in the majority of sawflies the greater part of the hind-wing is membranous and transparent ; the jugum, however, is

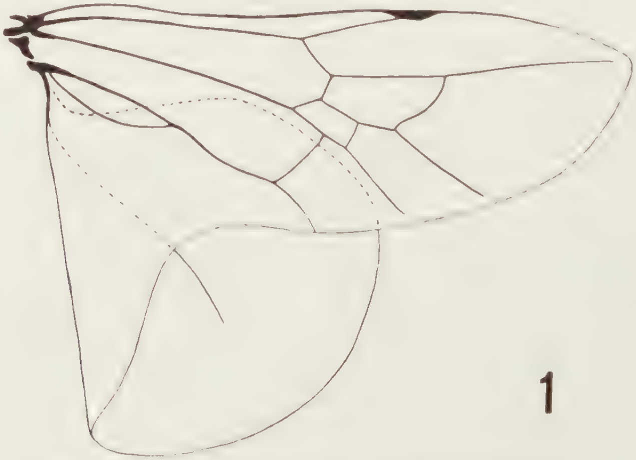

FIG. 1.—*Trochophora duckei* Konow, ♂, right hind-wing.

sclerotised, darkly pigmented and reflected beneath the main portion of the wing as an enlarged disc-like structure, suggestive of an extra wing or of a skeletal projection from the side of the abdomen. The wing figured (fig. 1) is that of a male taken on 7.i.1934, by Dr. J. G. Myers at Rupununi, British Guiana, but an enlarged jugum also occurs in the female.

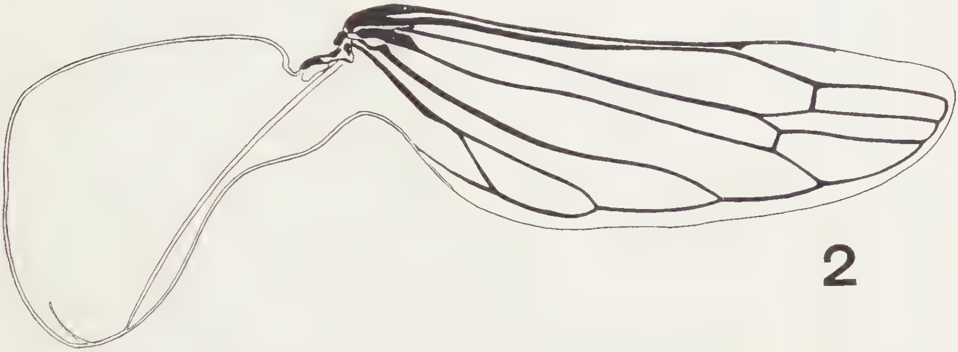

FIG. 2.—*Dilobopterus hexapterus* Burm., right hind-wing with jugum unfolded.

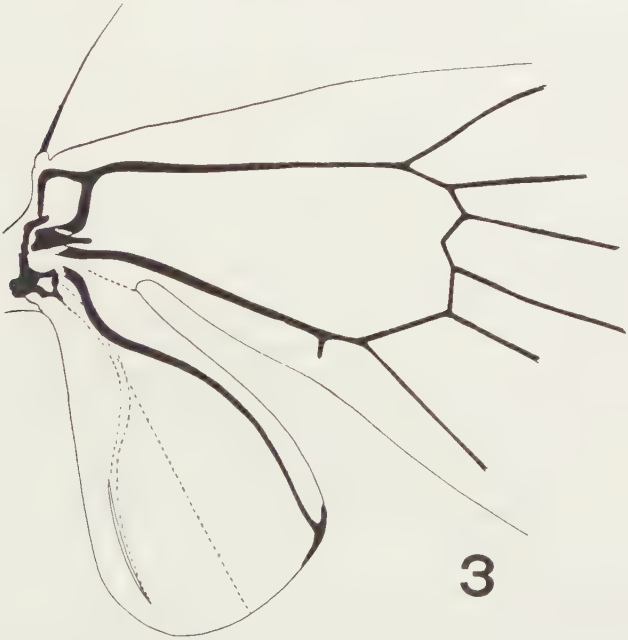

FIG. 3.—*Lobophora halterata* Hufn., ♂, base of right hind-wing with lobe unfolded.

An analogous structure is to be noted in both sexes of the Jassid genus *Dilobopterus,* of which several species are beautifully figured in colour by V. Signoret (1850, *Rev. Mag. Zool.,* (2) **2** : 283–9). In the hind-wings of the JASSIDAE the vannal fold occupies the typical position between the first and second anal veins, and the jugal fold lies behind the third anal vein. In *Dilobopterus trifasciatus* Sign. the jugum is not sharply separated from the rest of the wing, but in other species of the genus a deep incision of the membrane, extending along the jugal fold and reaching almost to its base, cuts off a distinct lobe which is reflected beneath the remaining part of the hind-wing as in the sawfly. In some species the jugum is almost circular, but in *D. hexapterus* Burm. from Brazil and Pará it is more elongate, and, as viewed from above in its natural position, concave. The main portion of the wing in *D. hexapterus* is hyaline, but the jugum has the basal third yellow and the distal half brownish, a transparent patch separating the two areas; it is supported by a jugal vein running near the anterior margin and by a marginal vein (fig. 2).

A common British insect in which the males have a well-developed anal lobe is the Geometrid moth *Lobophora halterata* Hufn., popularly known as the "Seraphim." In this species the lobe is supported anteriorly by the second anal vein and posteriorly by a vein-like thickening of the membrane probably associated with a scent-organ (fig. 3). In its natural position the posterior part of the lobe is folded beneath the anterior, and the whole organ is bent back upon the dorsal surface of the hind-wing. Homologous structures also occur in males of *Nothopteryx carpinata* Bork. and *Mysticoptera sexalisata* Hübn.

I am indebted to Sir Edward Poulton, F.R.S., for suggesting the above study, to Mr. W. E. China for directing my attention to the genus *Dilobopterus*, and to Messrs. R. B. Benson, W. E. China and L. B. Prout for much valuable assistance in the interpretation of my observations.

RELATIVE ACCEPTABILITY AND POISONOUS FOOD-PLANTS

By FRANK MORTON JONES, D.Sc., F.R.E.S.

IN two previous papers (1932, *Trans. ent. Soc. Lond.*, **80** : 345–386; 1934, *Trans. R. ent. Soc. Lond.*, **82** : 443–453) recording the results of experiments on the relative acceptability of various species of insects to birds, it was shown that some insects of gaudy coloration whose food-plants (*Asclepias*, *Apocynum*) contain poisons, are relatively unacceptable to birds of several species; and (thus eliminating the factor of coloration) that extracts of these same insects, when mixed into foods otherwise acceptable to ants, deter and prevent the ants from consuming those foods. To what extent these observed phenomena are due to the presence in the bodies of the insects of recently-eaten plant material, was not determinable by the experiments, though the fact that many other gaudily-coloured insects not having poisonous food-plants are likewise relatively unacceptable to birds, together with the observed behaviour of the birds in the acceptance and rejection of food, was interpreted to indicate that for birds at least the presence or absence in insects of freshly-consumed poisonous food is not the basis of recognition, but that for them recognition is usually visual.

Experiments to determine more definitely whether the deterrent properties of these insects depend upon recent feedings upon poisonous food-plants, were suggested by a boyhood recollection: the boy fisherman knows (or firmly believes) that his chances of catching a good string of fish with angleworms for bait are greatly increased if he puts the worms in sphagnum for a few days before using them, so that all earthy matter may be removed from their digestive tracts. The idea is not new, for old Izaak Walton instructs, "What worms soever you fish with, are the better for being well scoured, that is, long kept before they be used." It seemed worth while, then, to determine whether *Asclepias*- and *Apocynum*-feeding insects, long deprived of food, would still remain relatively unacceptable to birds, would still possess the same deterrent properties to ants.

In the summer of 1936, experiments were made with insects of these three species :

Tetraopes tetraophthalmus Frst. (Coleoptera, CERAMBYCIDAE), red and black, feeding on foliage of *Asclepias.*
Chrysochus auratus Fabr. (Coleoptera, CHRYSOMELIDAE), polished metallic green, feeding on foliage of *Apocynum.*
Labidomera clivicollis Kby. (Coleoptera, CHRYSOMELIDAE), yellow and black, feeding on foliage of *Asclepias.*

Insects of these three species were confined *without food* for five days, throughout which they seemed to retain their full strength and activity. At the termination of this period they were killed, marked inconspicuously for individual identification (usually by the removal of one or several joints of an antenna), and exposed as in previous experiments to the attacks of birds upon a feeding tray, together with others of the same species which had just been captured in the field upon these food-plants, and with a greater number of other insects of known acceptability. In these several experiments the results were the same : the insects of known ready acceptability were taken by the birds; those belonging to the three species named were left upon the tray uneaten, and not the slightest evidence appeared that any distinction between starved and freshly-fed individuals was recognised by the birds.

This had been the anticipated result; but would the ants be more sensitive to differences in the amount of poisonous plant material in the bodies of the insects? The results of this experiment seem worthy of report. Equal numbers of starved and of freshly-captured insects of each of these species were killed, dried under identical conditions, cut and crushed to fragments, and steeped for two hours in water (15 c.c. of water to 3 insects). Portions of the six infusions were strained and added to like amounts of fresh cream; and check-tests of equal parts of water and cream were provided for. Small portions (ten drops) of the infusions were evenly spaced on a horizontal porcelain plate, with six check-tests of water and cream similarly spaced among them. The plate was deposited on the floor of a room frequented by ants (*Solenopsis molesta*). As the ants assembled, the plate was turned and tapped from time to time, to cause a general dispersal of ants over its surface until their paths of communication to each sample should have become established. At the expiration of four hours the plate was swarming with ants, some of the samples were being rapidly consumed, and tabulations were commenced of the conditions prevailing at each sample. Five tabulations were made at hourly intervals, and finally (night intervening) the condition of the various samples at the expiration of fifteen hours from the first exposure was recorded, with these results :

	Average number (nearest full number) of ants present at five hourly observations.
Cream containing infusions of freshly-fed insects :	
Tetraopes tetraophthalmus	0
Chrysochus auratus	7
Labidomera clivicollis	1
Cream containing infusions of starved (5 days) insects :	
Tetraopes tetraophthalmus	0
Chrysochus auratus	2
Labidomera clivicollis	0
Six check-tests, cream with equal parts of water :	
Ants too numerous to count with accuracy, but average certainly in excess of 100.	

The next morning (fifteen hours after exposure) the condition of the twelve samples was examined. All six of the check-tests (cream and water) had been consumed, ants still swarmed over the spots where the check-tests had been placed, though on only one of the six was a faint film discernible. None of the six samples of cream combined with insect infusions showed observable diminution in bulk, and the number of ants present at them averaged only four ants per sample. It should be recalled that the similar experiments of 1932 demonstrated that only a small proportion of insect species possess these ant-deterrent qualities. If any significance attaches to the presence of a few more ants on the samples containing the infusions of *auratus* in comparison with the two other, it would seem to be that the secretions of that insect or the qualities of its food-plant (*Apocynum*), are not as deterrent as those of the other two which feed upon *Asclepias*. The general result seems unmistakable and conclusive, that these three insects retain their deterrent qualities, without regard to whether they have recently fed upon poisonous plant material or have been deprived of such food for considerable periods of time.

If with vertebrate enemies of insects recognition is usually visual, but if back of visual recognition there exists the possibility of avoidance or refusal determined by taste or odour, then from these experiments it would appear that these insects, wandering from their food-plants by chance, through exhaustion of the supply, for mating or for ovipositing, retain their protective characters, not only of coloration, but probably also those of odour or taste, whether these latter are based upon insect secretions or upon direct but persisting products of their food.

[Communicated, in the absence of the author, by Sir EDWARD POULTON, who referred to the interesting relationship between Dr. Morton Jones's experiments here described, and those conducted by Dr. H. Eltringham and published in our *Transactions* for 1909 (**1909** : 471–8). While the former proved conclusively that the distasteful qualities of the aposematic beetles did not depend upon a deterrent food-material present in the digestive tract, the latter strongly suggested that the procryptic larvae were refused for this very reason, as shown by the following condensed quotation from Dr. Eltringham's description of his experiments with *Lacerta viridis* and the larvae of *Boarmia rhomboidaria* when fed on ivy and on apple.

" I am quite convinced by carefully watching the lizards that ivy-fed larvae of *Boarmia rhomboidaria* are extremely distasteful, and I am equally persuaded that when fed for a time on apple those distasteful qualities are removed. Ivy-fed larvae were tasted and refused with disgust seventeen times, and eaten five times. . . . In the cases where the larva was eaten, it was consumed with hesitation and evident lack of relish, whilst once it was eaten under stress of competition. . . . In strong contrast to this behaviour is the fact that apple-fed larvae were eaten in every case in which they were tasted, . . . [being] always swallowed uninterruptedly and without any of the characteristic nose-rubbing and other contortions which accompanied the dealings with those fed on ivy " (pp. 477–8).]

A COLLECTION OF INSECTS AND ARACHNIDS MADE ON BOARD H.E.M.S. "MABAHISS" DURING THE JOHN MURRAY EXPEDITION, 1933–1934

By T. T. MACAN, M.A.

Communicated by Dr. A. D. IMMS, M.A., Sc.D., F.R.S., F.R.E.S.

THE insects in this collection fall into two categories :—

(i) Ship-inhabiting species, (ii) Other species.

(i) SHIP-INHABITING SPECIES.

Orthoptera.		*Blatella germanica* (L.).	Very abundant everywhere on board.
		Blatta orientalis L.	Present in large numbers, though much less abundant than the preceding.
Coleoptera.	DERMESTIDAE.	*Dermestes cadaverinus* L.	One specimen.
	CLERIDAE.	*Necrobia rufipes* de G.	Many specimens flew on to the ship as she lay in Aden harbour (x.33) about a quarter of a mile from the shore. None was seen later in the voyage.
	BRUCHIDAE.	*Bruchus pisorum* L.	One specimen.

Pseudoscorpiones. One specimen found inside "Manual of Navigation."

(ii) OTHER SPECIES.

Captures of insects not belonging to the ship's permanent fauna are tabulated below together with the date, the ship's position at the time, her previous movements, and the wind force and direction. Distances are in nautical miles.

9.x.33. At anchor 1 mile from coast of Italian Somaliland.
Musca domestica L. came on board in large numbers, and a few were still to be found ten days later.

14.x.33. 70 miles from Arabia, 125 miles from Africa, steaming N. across Gulf of Aden; light airs.
Hemianax ephippiger Burm. 1 specimen.

15.x.33. Steaming W., parallel to and distant 35 miles from N. coast of Gulf of Aden; wind E., 11–16 m.p.h.
Hemianax ephippiger Burm. 1 ♂.

20.x.33. Aden harbour, lying about a quarter of a mile off the shore.
Acrosternum sp. 1 specimen.

16.xi.33. Karachi harbour, lying alongside.
Blepharopsis mendica (Fabr.) subsp. *nuda* Giglio-Tos. 1 specimen.
Dieuches armipes Fabr. 1 specimen.
Eysarcoris inconspicuus H.S. 1 specimen.
Orthaea andrewsi Dist. 1 specimen.
Semiothisa streniataria Walk. 1 ♂, 1 ♀.
Oligochroides akbarella Rag. 1 ♀.
Nymphula affinialis Guenée. 1 specimen.
Eretes sticticus L. 1 specimen.

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18.xi.33. 150 miles from land, outward bound from Karachi on S.W. course; wind N.E., 11–16 m.p.h.
Anacridium aegyptium (L.). 1 specimen.
Pyrgomorpha sp. 1 specimen.
Gryllotalpa africana (Beauv.). 1 specimen.
Mantis religiosa L. 1 specimen.
Hemianax ephippiger Burm. 1 ♂, 2 ♀♀.
Microdus sp. 1 ♀.

24.xi.33. Steaming W., parallel to and distant 20 miles from N. coast of Gulf of Oman; wind S.E., 7–11 m.p.h.
Anacridium aegyptium (L.). 1 specimen.
Aphanus sordidus Fabr. 1 specimen.
Hemianax ephippiger Burm. 1 ♀.
Crocothemis erythraea Brullé. 1 ♀.

8.xii.33. Bound from Arabian coast to Bombay, India distant 60 miles; wind E.N.E., 7–11 m.p.h.
Carecomotis properata Walk. 1 ♀.

18.xii.33. Bound from Bombay to Mombasa, nearest land distant 700 miles.
Thriptera crinita Klug. 1 specimen.

iii.34. *Isometrus maculatus* (de G.). 1 specimen found in gear used ashore on Maldives.

4.iv.34. At anchor in Horsburgh atoll (Maldives).
Clinopogon scalaris Bigot. A large number came on board but disappeared a few days after the ship left the atoll.

12.iv.34. Steaming from Minikoi to Colombo, Minikoi distant 225 miles, Ceylon 150 miles, India 40 miles; wind S. by W., 11–16 m.p.h.
Zizeeria otis decreta Butler. 1 ♀.

It is impossible to determine how far the insects flew and how far they rode on the ship, but clearly ability to do either successfully might result in wider distribution. In the table below, the data are rearranged to give the maximum value for each of these two modes of travel; column 5 shows the maximum distance each insect must have flown on the assumption it had alighted on the ship shortly before capture, and column 6 shows the maximum time it must have spent on board on the assumption that it had joined the ship on the last occasion when she lay at anchor within a few cables of the land. In certain cases where the species is known to be a feeble flier or where numbers were observed on the ship while still at anchor, the figure for column 5 is put in brackets or omitted altogether.

The wind direction relative to the insects' path assuming that it had come straight from the nearest land is given. A track chart is appended to vol. 1, pt. 1, of the reports of the Expedition.

Dragonflies were seen flying round the ship on many occasions, on one nearly six hundred miles from land. It is probable that the remaining insects did most of their travelling as passengers. *Thriptera crinita* is interesting since it is an apterous desert living beetle and when found had almost certainly been on board at least three weeks, for, although the "Mabahiss" was only a week out of Bombay, it is likely that the insect had been brought on board from the Arabian coast or even Karachi. No other insect survived as long as this, but several travelled successfully for some days, and this suggests that if other vessels carry as many insects as the " Mabahiss " they must play quite an important part in the distribution of certain species other than those which are regular inhabitants.

Order.	Family.	Species.	Date.	Distance from land.	Time from land.	Wind.
Orthoptera	ACRIDIDAE	*Anacridium aegyptium* (L.)	18.xi.33	150 miles	18 hrs.	following
			24.xi.33	20 ,,	12 ,,	head
		Pyrgomorpha sp.	18.xi.33	150 ,,	18 ,,	following
	GRYLLIDAE	*Gryllotalpa africana* (Beauv.)	,,	,, ,,	,, ,,	,,
	MANTIDAE	*Mantis religiosa* L.	,,	(,, ,,)	,, ,,	,,
		Blepharopsis mendica subsp. *nuda* Giglio-Tos	16.xi.33	Karachi harbour		
Odonata		*Hemianax ephippiger* Burm.	14.x.33	70 miles	2 days	light airs
			15.x.33	35 ,,	3 ,,	side
			18.xi.33	150 ,,	18 hrs.	following
			24.xi.33	20 ,,	12 ,,	head
		Crocothemis erythraea Brullé	,,	,, ,,	,, ,,	,,
Hemiptera	PENTATOMIDAE	*Acrosternum* sp.	20.x.33	1/4 ,,	Aden harbour	
		Eysarcoris inconspicuus H.S.	16.xi.33	Karachi harbour		
	LYGAEIDAE	*Orthaea andrewsi* Dist.	,,	,, ,,		
		Dieuches armipes Fabr.	,,	,, ,,		
		Aphanus sordidus Fabr.	24.xi.33	20 miles	12 hrs.	head
Lepidoptera	GEOMETRIDAE	*Carecomotis properata* Walk.	8.xii.33	60 ,,	7 days	,,
		Semiothisa streniataria Walk.	16.xi.33	Karachi harbour		
	PYRALIDAE	*Oligochroides akbarella* Rag.	,,	,, ,,		
		Nymphula affinialis Guenée	,,	,, ,,		
	LYCAENIDAE	*Zizeeria otis decreta* Butler.	12.iv.34	(40 miles)	24 hrs.	head
Coleoptera	DYTISCIDAE	*Eretes sticticus* L.	16.xi.33	Karachi harbour		
	TENEBRIONIDAE	*Thriptera crinita* Klug.	17.xii.33	—	3 weeks	—
Hymenoptera		*Microdus* sp.	18.xi.33	150 miles	18 hrs.	following
Diptera	ASILIDAE	*Clinopogon scalaris* Bigot.	4.iv.34	—	3 days	—
	MUSCIDAE	*Musca domestica* L.	9.x.33	—	10 ,,	—
ARACHNIDA	SCORPIONIDAE	*Isometra maculata* (de G.)	iii.34	—	1 day	—
	IXODIDAE	*Amblyomma* sp.		Locality not recorded		

Insects found in Plankton nets.

Psocoptera.	*Pterodela* (*Lachesilla*) *pedicularia* (L.). st. 58 1 ♂, st. 186 1 ♀.
Ephemeroptera.	*Baetis* sp. ? st. 172, 2665 m. 1 nymph.
Hemiptera.	*Halobates sewelli* Imms. st. 61.
Trichoptera.	*Hydropsyche* sp. st. 61, 1133 m. 1 larva.

Mr. J. V. Pearman, who named the Psocids, suggested that they probably drowned themselves in the sorting dishes in England. A similar explanation cannot be advanced for the mayfly nymph and the caddis larva and their appearance in the plankton remains a mystery. It should be noted that the nets were not self-closing and fished all the way up to the surface.

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BOOK NOTICE.

Culture methods for Invertebrate animals. A compendium prepared co-operatively by American zoologists under the direction of a committee from Section F of the American Association for the Advancement of Science. Ithaca, New York. Comstock Publishing Co. Inc., 1937. $4.00.

This volume is a compendium of 313 articles on the rearing of invertebrate animals prepared by specialists in nearly every field of applied zoology. It ranges from the Protozoa to the Chordata, of which almost one half is devoted to the Insecta. At least one species of every considerable group of invertebrates is represented, and chapters deal with general considerations of culture management and detailed methods of collecting and rearing particular groups or species.

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